Use of Conducting Polymers for Electronic Communication with Redox Active Nanoparticles

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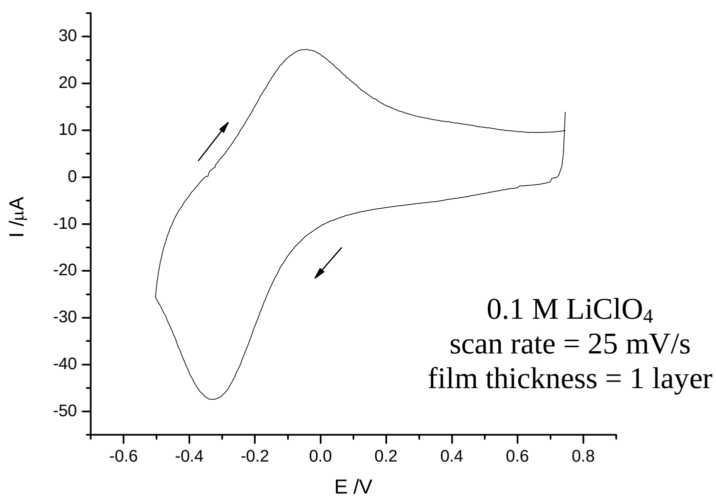
Nanoscale materials provide unique properties that will enable new technologies and enhance older ones. One area of intense activity in which nanoscale materials are being used is in the development of new functional materials for battery applications.[1-4] This effort promises superior materials with properties that circumvent many of the problems associated with traditional battery materials.

Previously we have worked on several approaches for using nanoscale materials for application as cathode materials in rechargeable Li batteries.[5-11] Our recent work has focused on synthesizing MnO_2 nanoparticles and using conducting polymers to electronically address these particles in nanoparticle assemblies. This presentation will focus on those efforts.

MnO_2 nanoparticles that are encapsulated with poly(3,4-ethylenedioxythiophene) (PEDOT) are prepared using 3,4-ethylenedioxythiophene (EDOT) as a chemical reductant for permanganate anion. This non-aqueous preparation is based on a recent report of a similar method for preparation of PEDOT-encapsulated Au nanoparticles.[12] We also describe the synthesis of MnO_2 colloidal nanoparticles prepared using an aqueous route involving reduction of permanganate anion with butanol using a previously described route.[13] We report the synthesis and characterization of the PEDOT material, and the aqueous colloidal material. We show that the aqueous colloidal nanoparticles can be trapped in thin films using a layer-by-layer deposition approach, and that these films are both redox active and exhibit kinetically facile electrochemical responses. This is illustrated in Figure 1 below, which shows cyclic voltammetry of MnO_2 colloidal nanoparticles entrapped in a thin film at an ITO electrode surface using poly(diallyldimethylammonium chloride (PDDA). Finally, we report on the use of X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) to characterize the oxidation state and coordination environment around Mn in these materials.



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(1) Martin, C. R.; Mitchell, D. T. *Electroanal. Chem.* **1999**, *21*, 1-74.
(2) Polzot, P.; Laruelle, S.; Grugeon, S.; Dupont, L.; Tarascon, J. M. *Nature (London)* **2000**, *407*, 496-499.
(3) Nazar, L. F.; Goward, G.; Leroux, F.; Duncan, M.; Huang, H.; Kerr, T.; Gaubicher, J. *International Journal of Inorganic Materials* **2001**, *3*, 191-200.
(4) Sides, C. R.; Li, N.; Patrissi, C. J.; Scrosati, B.; Martin, C. R. *MRS Bulletin* **2002**, *27*, 604-607.
(5) Shouji, E.; Buttry, D. A. *Langmuir* **1999**, *15*, 669-673.
(6) Huguenin, F.; Do Prado Gambardella, M. T.; Torresi, R. M.; De Torresi, S. I. C.; Buttry, D. A. *J. Electrochem. Soc.* **2000**, *147*, 2437-2444.
(7) Holland, G. P.; Huguenin, F.; Torresi, R. M.; Buttry, D. A. *J. Electrochem. Soc.* **2003**, *150*, A721-A725.
(8) Holland, G. P.; Yarger, J. L.; Buttry, D. A.; Huguenin, F.; Torresi, R. M. *J. Electrochem. Soc.* **2003**, *150*, A1718-A1722.
(9) Huguenin, F.; Girotto, E. M.; Torresi, R. M.; Buttry, D. A. *J. Electroanal. Chem.* **2002**, *536*, 37-45.
(10) Huguenin, F.; Torresi, R. M.; Buttry, D. A. *J. Electrochem. Soc.* **2002**, *149*, A546-A553.
(11) Huguenin, F.; Torresi, R. M.; Buttry, D. A.; da Silva, J. E. P.; de Torresi, S. I. C. *Electrochim. Acta* **2001**, *46*, 3555-3562.
(12) Li, X.; Li, Y.; Tan, Y.; Yang, C.; Li, Y. *J. Phys. Chem. B* **2004**, *108*, 5192-5199.
(13) Brock, S. L.; Sanabria, M.; Suib, S. L.; Urban, V.; Thiyagarajan, P.; Potter, D. I. *J. Phys. Chem. B* **1999**, *103*, 7416-7428.